

missiles at military and NASA centers. The relatively large signals noted in some spectra plots in the vicinity of 2380 MHz were examined and found to be very narrowband, and therefore it is unlikely that they are artifacts of 2400-2500 MHz ISM equipment transmissions. Secondly, over the band of principal interest, 2400-2500 MHz, the primary usage was concentrated toward the upper part of the band (e.g. 2420-2500 MHz), and peak signals were generally noted in the 2450-2460 MHz region. In general, the shape of the aggregate signal spectrum was consistent with that noted in the single microwave oven tests described in reference 4. Finally, the upper part of the monitored band (2500-2600 MHz) shows significant activity, especially in the Los Angeles CA data. These frequencies are employed for "wireless cable" entertainment programming in Multichannel Multipoint Distribution Service (MMDS), closed circuit educational TV transmissions in the Instructional Television Fixed Service (ITFS), and private video teleconferencing.

**b) Background and Dominant Oven Environments:** Two types of aggregate ISM environment were noted: background only, without dominant oven sources, and background with dominant oven sources. As described later in this report, the former environment had the characteristics of gaussian noise, while the latter included a component identical to the signals observed during the single oven testing (reference 4).

**c) Diurnal Variation:** Data sets were collected hourly over a 24 hour period. The background ISM signal did not display any noticeable variation with time-of-day. As shown in Figures 2 through 5, the data collected at the Los Angeles location, away from any "dominant oven" sources reveals a 2400-2500 MHz usage that is fairly devoid of diurnal cycling. Although the case could be made that use of the band did decrease during the very early morning (e.g. 1-4 AM) hours, the reduction was not significant. This could be due to there being a variety of applications for domestic microwave ovens apart from just meal cooking, or the full time operations of industrial or commercial ISM equipment.

In the downtown location, spectrum monitoring did reveal an apparent diurnal cycle, where the signal peaked during the morning, noon and evening hours (see Figures 6 through 9). These periods coincide with the breakfast/lunch/dinner periods, and close scrutiny of the data revealed that the spectral amplitudes of the aggregate signal were being influenced by signals from nearby dominant oven sources. As most of these dominant oven sources were located in restaurants in the area, their usage obviously did follow a diurnal cycle, resulting in a cycling of the monitored aggregate signal.

**d) Aggregate Signal Amplitude:** Statistically, the aggregate signal at any given frequency is similar to gaussian noise -- albeit at an elevated level. This assertion is supported both by the shape of the signal amplitude probability distributions (see Figures 10 and 11), and the approximately  $10\log(BW1/BW2)$  relationship evident between measurements performed

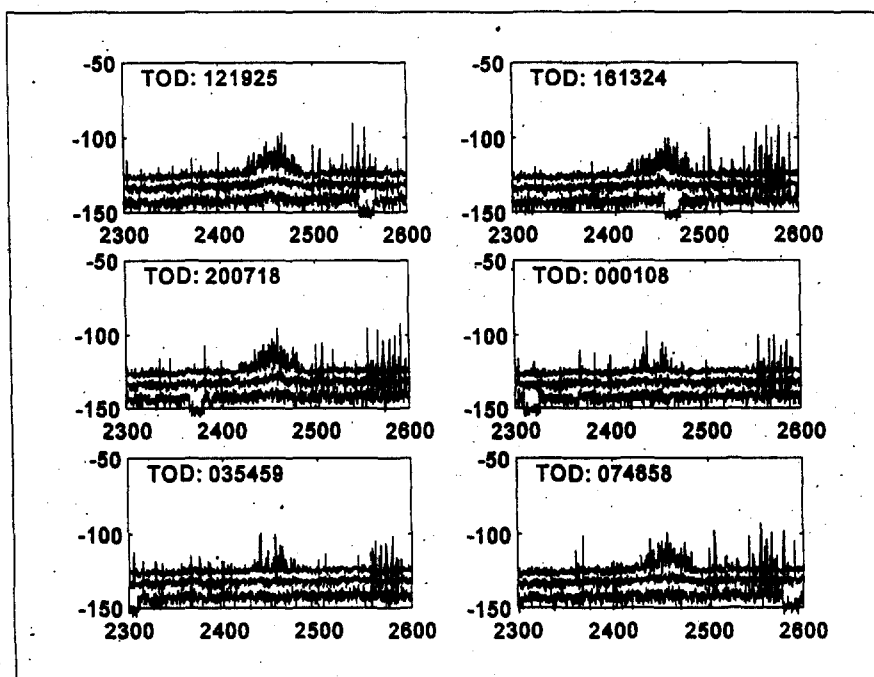


Figure 2: Diurnal Variation in 2300-2600 MHz Spectral Usage, Sample Mode, 30 kHz Receiver BW, Los Angeles CA Data, Amplitude (dBm) vs Frequency(MHz)

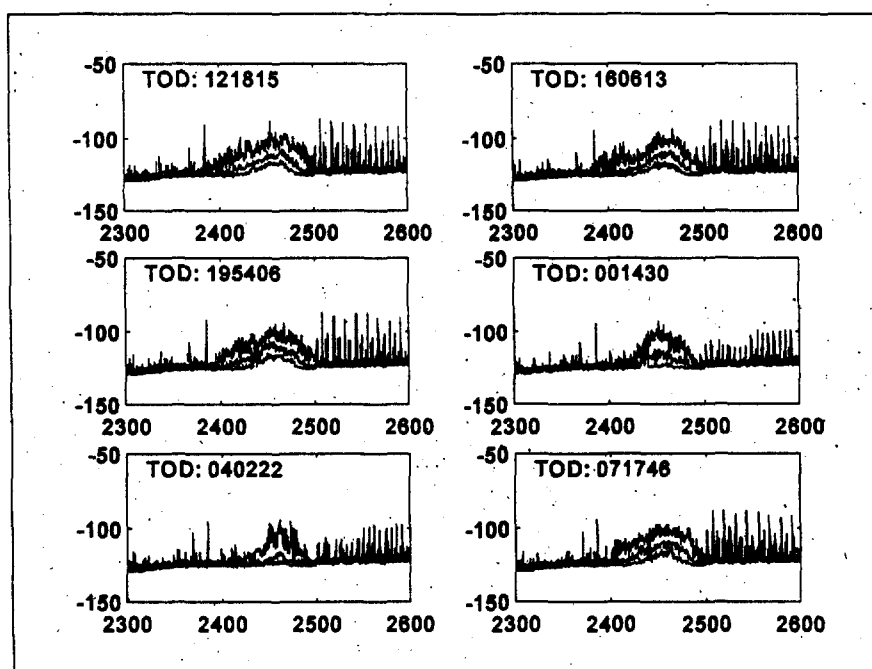


Figure 3: Diurnal Variation in 2300-2600 MHz Spectral Usage, +Peak Mode, 30 kHz Receiver BW, Los Angeles CA data, Amplitude(dBm) vs Frequency(MHz)

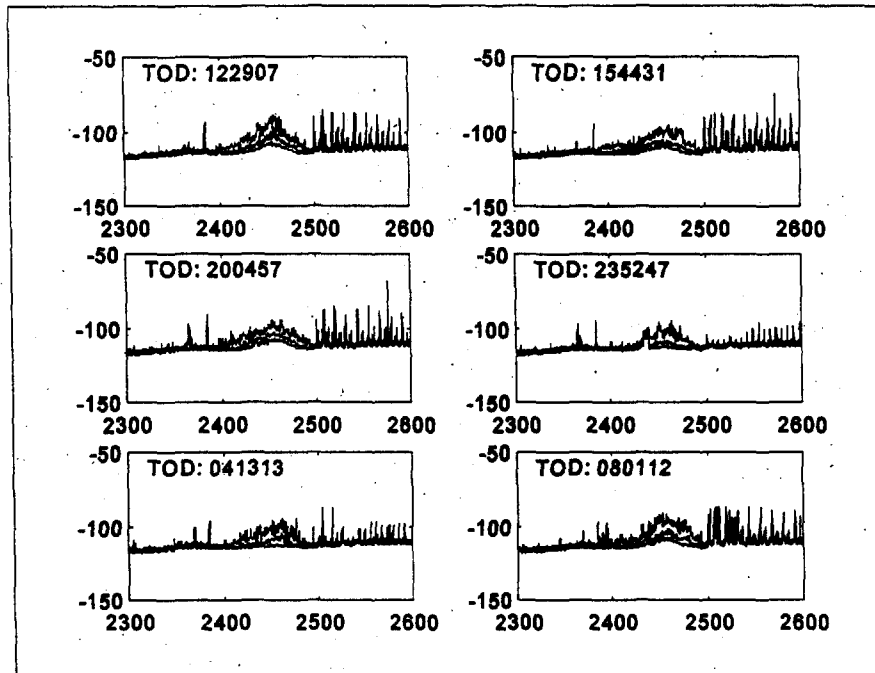


Figure 4: Diurnal Variation in 2300-2600 MHz Spectral Usage, +Peak Mode, 300 kHz Receiver BW, Los Angeles CA Data, Amplitude(dBm) vs Frequency(MHz)

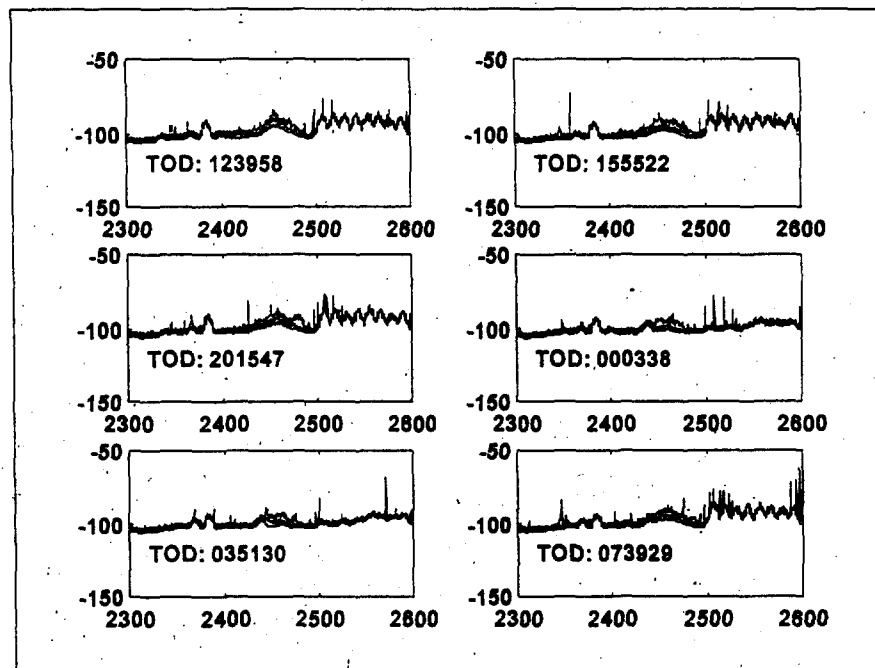


Figure 5: Diurnal Variation in 2300-2600 MHz Spectral Usage, +Peak Mode, 3 MHz Receiver BW, Los Angeles CA Data, Amplitude(dBm) vs Frequency(MHz)

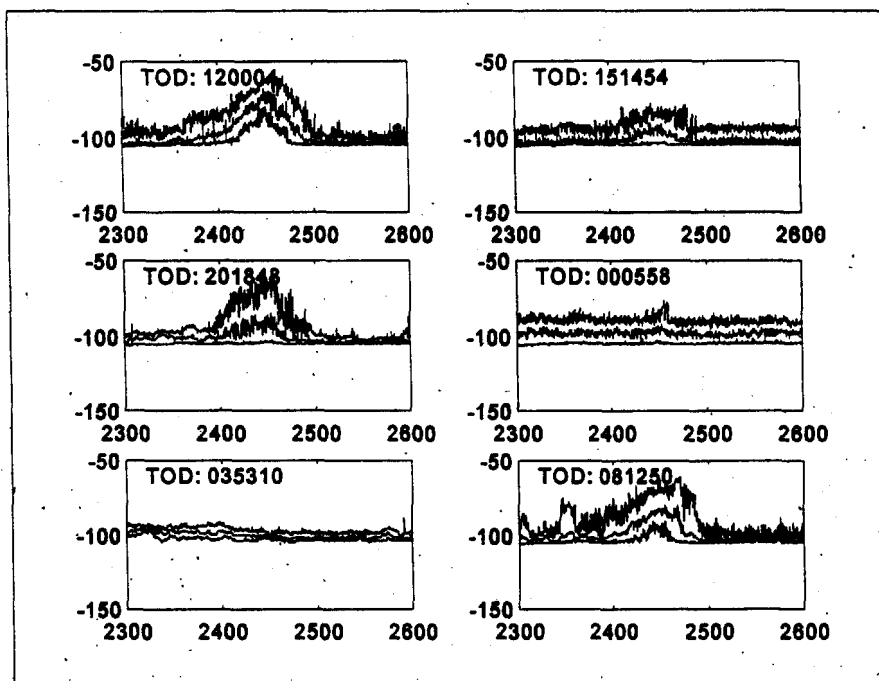


Figure 6: Diurnal Variation in 2300-2600 MHz Spectral Usage, +Peak Mode, 300 kHz Receiver BW, Downtown Denver CO Data, Amplitude(dBm) vs Frequency(MHz)

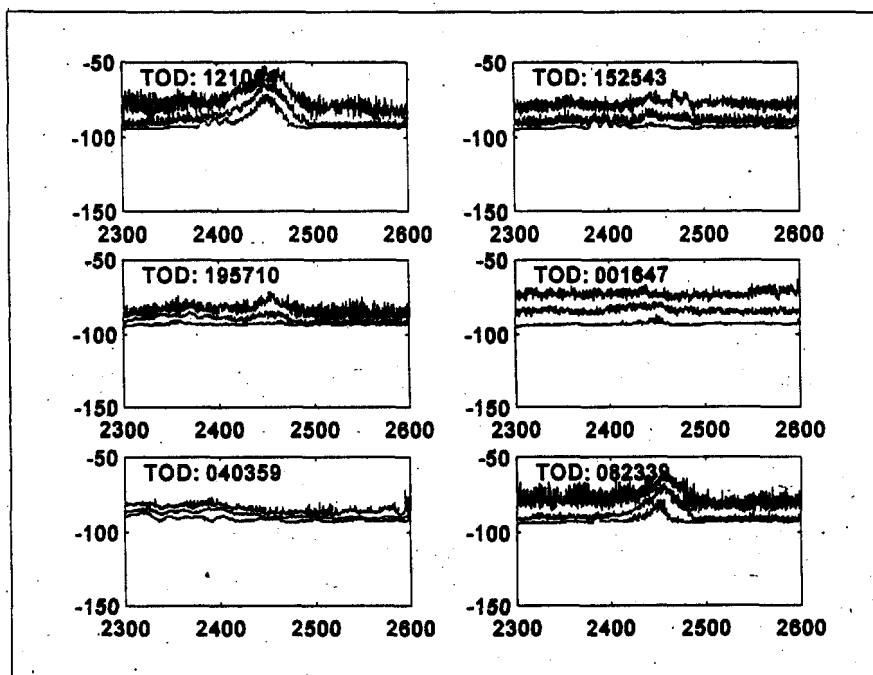


Figure 7: Diurnal Variation in 2300-2600 MHz Spectral Usage, +Peak Mode, 3 MHz Receiver BW, Downtown Denver CO Data, Amplitude(dBm) vs Frequency(MHz)

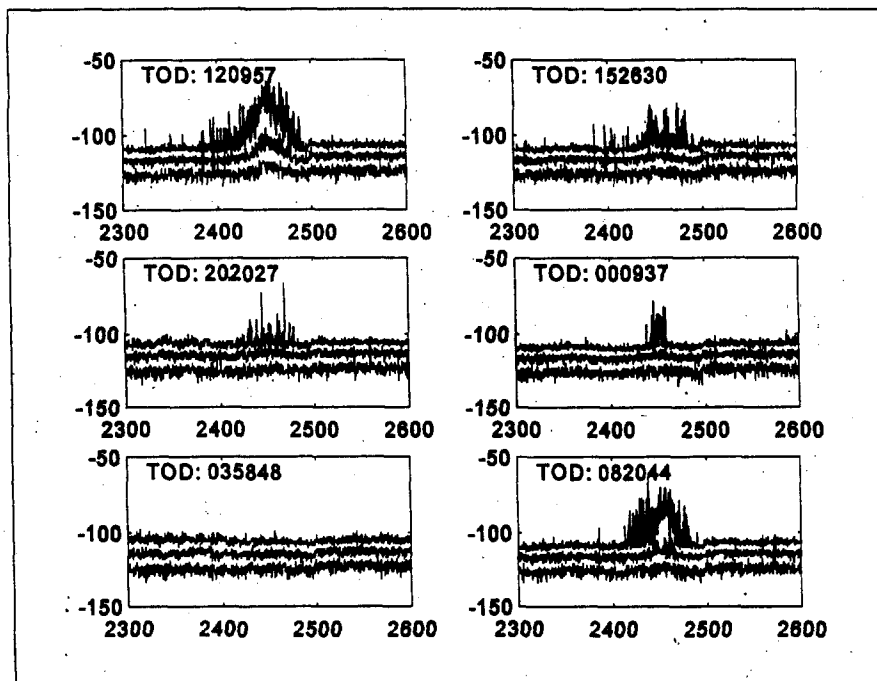


Figure 8: Diurnal Variation in 2300-2600 MHz Spectral Usage, Sample Mode, 300 kHz Receiver BW, Downtown Denver CO Data, Amplitude(dBm) vs Frequency(MHz)

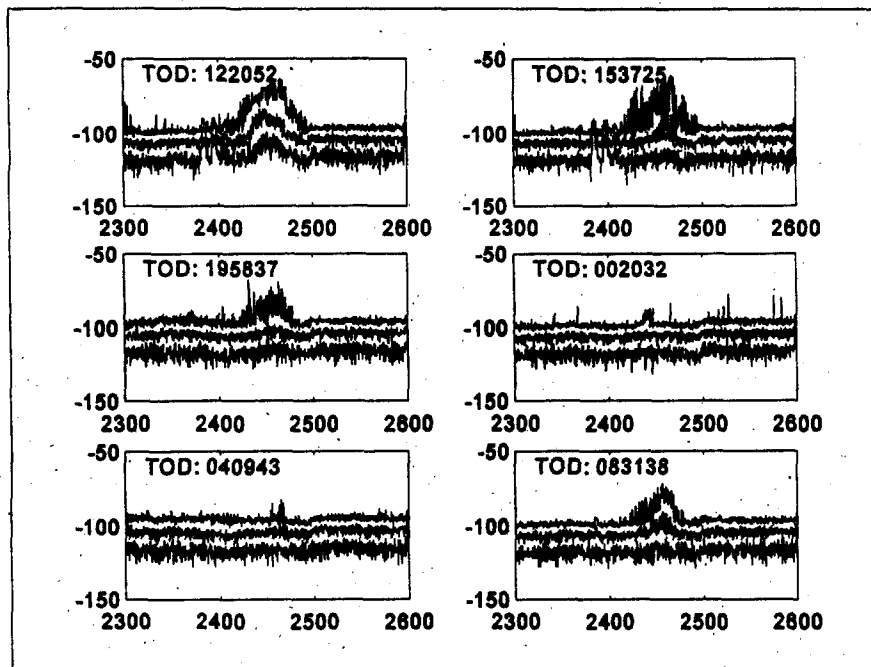


Figure 9: Diurnal Variation in 2300-2600 MHz Spectral Usage, Sample Mode, 3 MHz Receiver BW, Downtown Denver CO Data, Amplitude(dBm) vs Frequency(MHz)

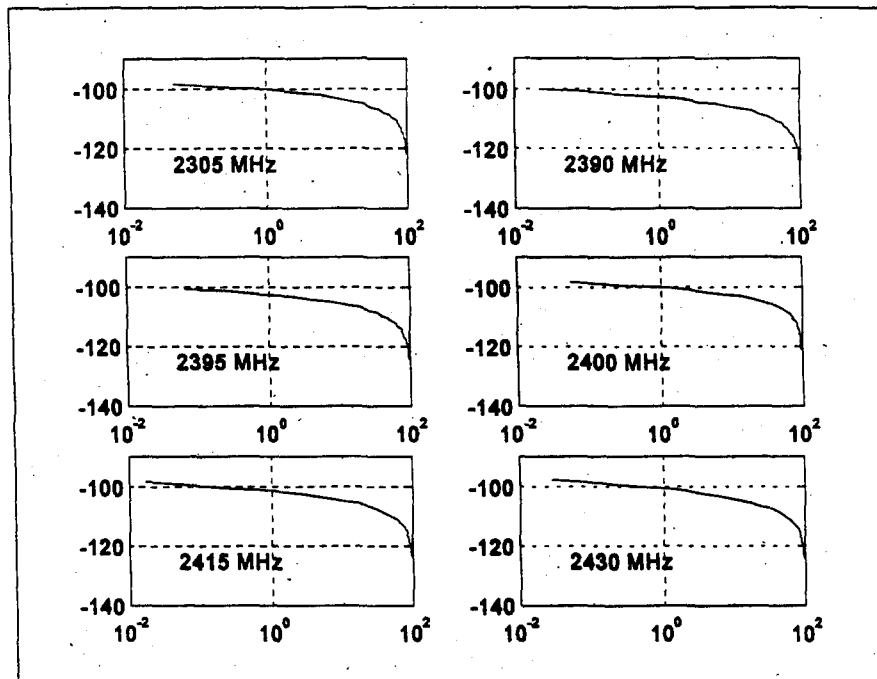


Figure 10: Amplitude Probability Distributions, Indicated Frequency, Sample Mode, 3 MHz Receiver BW, Los Angeles CA Data, Amplitude(dBm) vs Percentage of Samples Exceeding that Amplitude

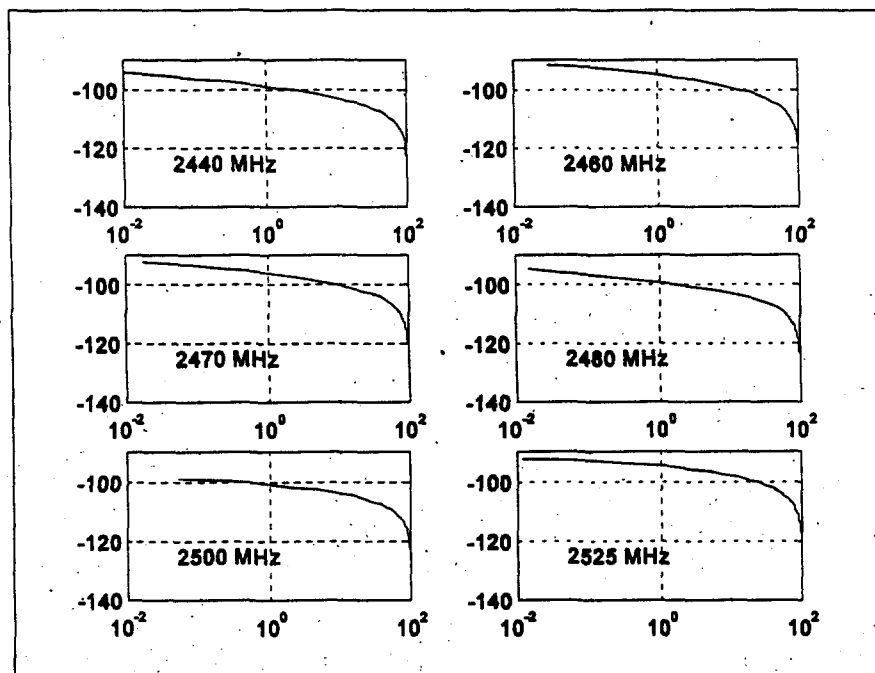


Figure 11: Amplitude Probability Distributions, Indicated Frequency, Sample Mode, 3 MHz Receiver BW, Los Angeles CA Data, Amplitude(dBm) vs Percentage of Samples Exceeding that Amplitude

with varied receiver bandwidths (see Figures 12-13 and Table 2). As with the diurnal variation data, this characterization is tempered somewhat when "dominant oven" signals are evident. As shown in Figure 14, signals from those dominant oven sources appear identical to those measured in the single-oven tests, though riding on an elevated noise floor. These dominant oven signals result in the "second hump" apparent in some APDs of the time waveform data (see Figure 15). This feature is not as evident in the APDs of data collected far from those dominant sources.

**Table 2: Measured Amplitude Probability Distribution Values, LA Data, Sample Mode, 2450 MHz**

-136	-128	-122	-113	-100.5
-130	-122	-116	-108	-96
-124	-116	-108	-102	-94
-118	-110	-104	-99	-94
-114	-106	-100	-96	-91

**e) Omni versus Directional Antennas:** As described above, a limited amount of testing was performed to determine whether the aggregate ISM signal characteristics would be altered by the utilization of a directional receive antenna instead of an omni-directional antenna. Using two spectrum analyzers, one connected to a directional antenna and the other connected to an omni antenna, simultaneous measurements of the aggregate signal environment were made. For aggregate signal sources which are distributed uniformly within an area around the measurement system receiver and/or the desired signal source, there does not appear to be much of an advantage to utilizing a directional antenna (see Figures 16 through 18). This is a result of the fact that while the directional antenna allows for spatial discrimination of the aggregate signal, the increased directive gain of the antenna more than compensates for that spatial attenuation. If however the desired signal source is in a different direction from the sources comprising the aggregate signal, the directivity of the antenna could provide an advantage. Use of the directional antenna did not appear to result in any change in the number of "dominant oven" sources detected.

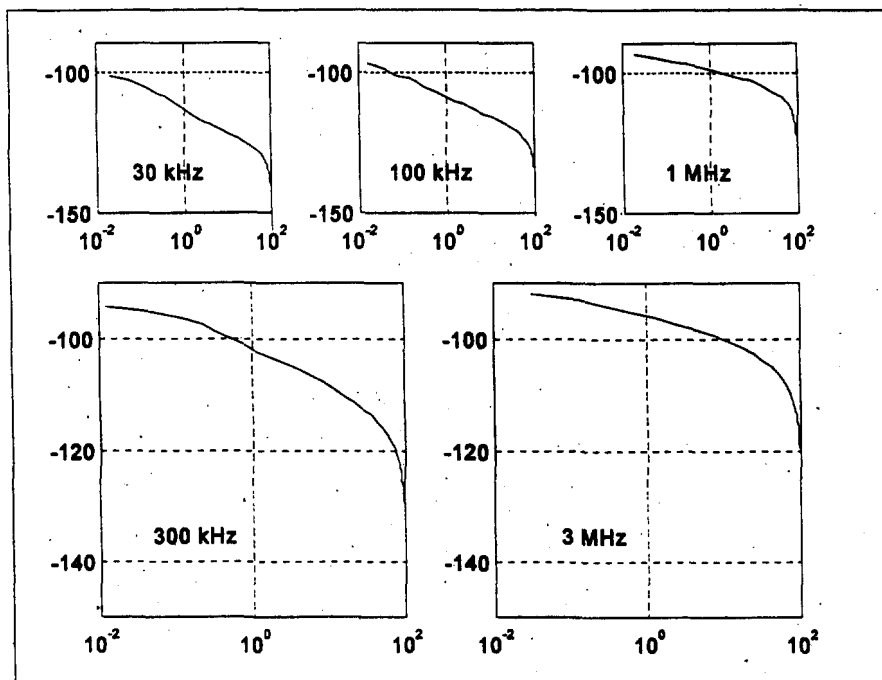


Figure 12: Amplitude Probability Distributions, 2450 MHz, Sample Mode, Indicated Receiver BW, Los Angeles CA Data, Amplitude(dBm) vs Percentage of Samples Exceeding that Amplitude

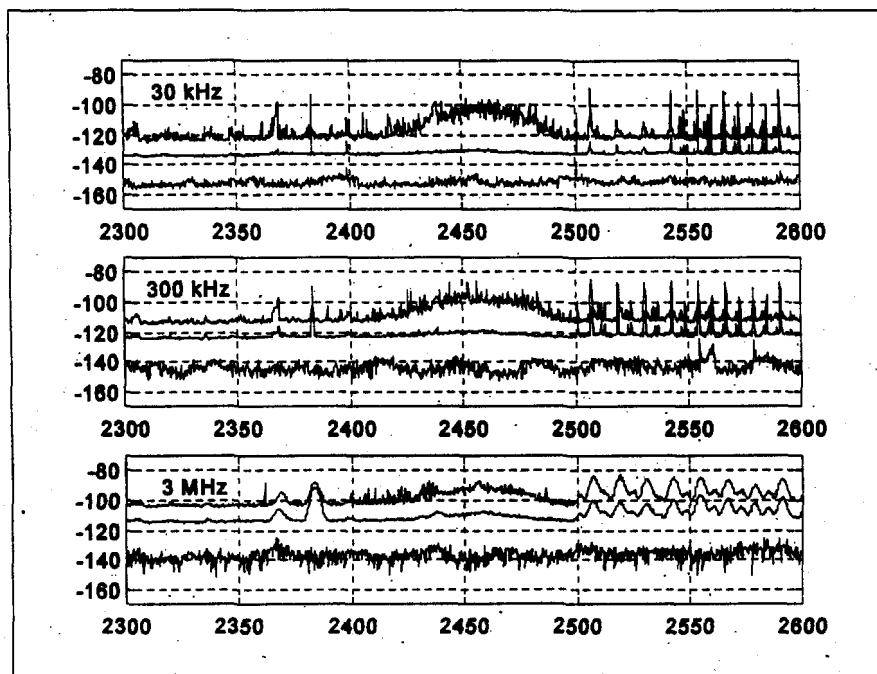


Figure 13: Cumulative Spectral Usage, Sample Mode, Indicated Receiver BW, Los Angeles CA Data, Min of mins, Mean of means, and Max of maxes, Amplitude(dBm) vs Frequency(MHz)

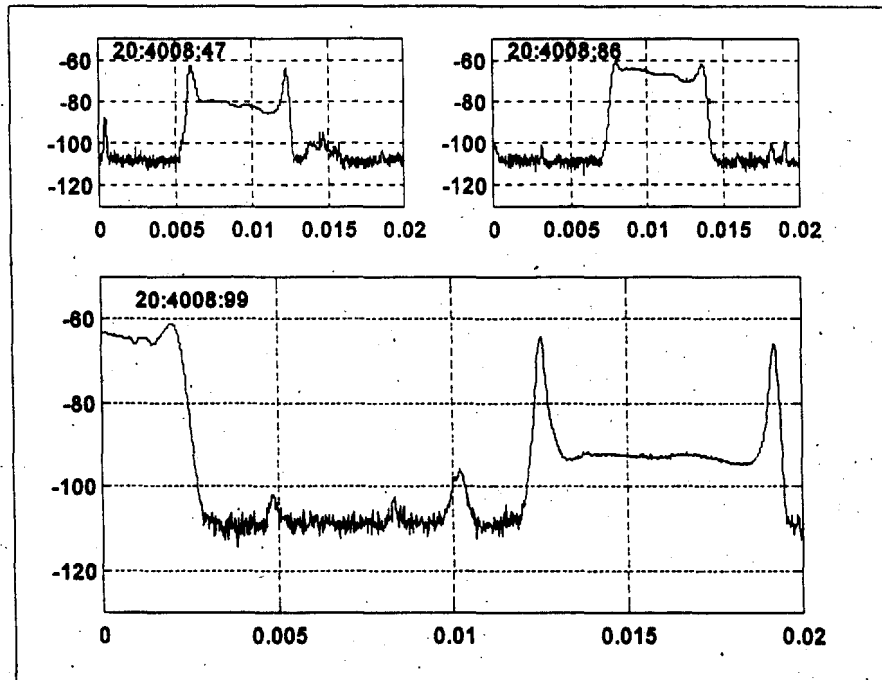


Figure 14: Sample "Dominant Oven" Time Waveforms, 2460 MHz, +Peak Mode, 300 kHz Receiver BW, Downtown Denver CO Data, Amplitude (dBm) vs Time (sec).

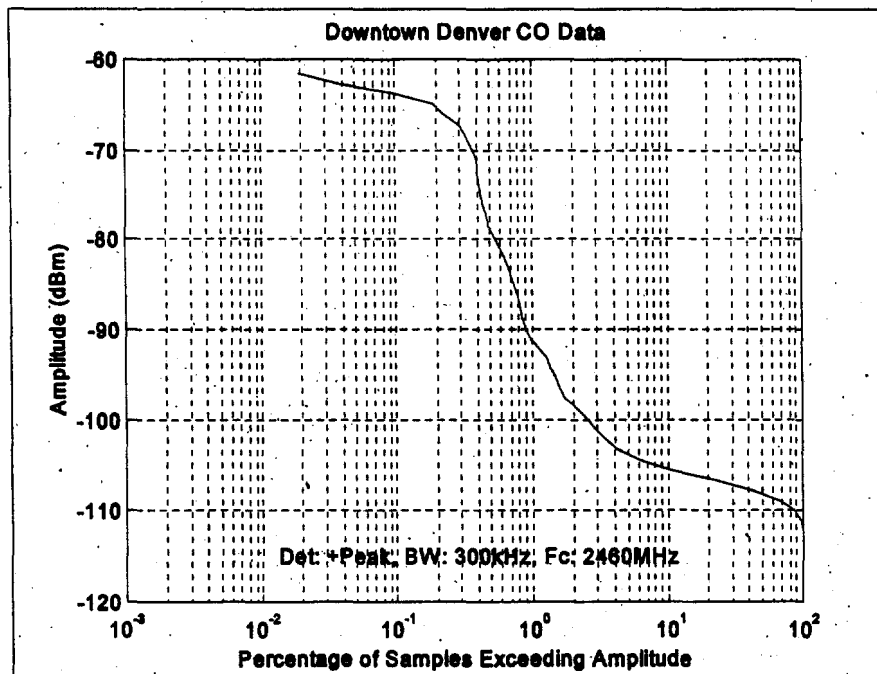


Figure 15: Example of "Dominant Oven" Effect on Signal Amplitude Probability Distribution

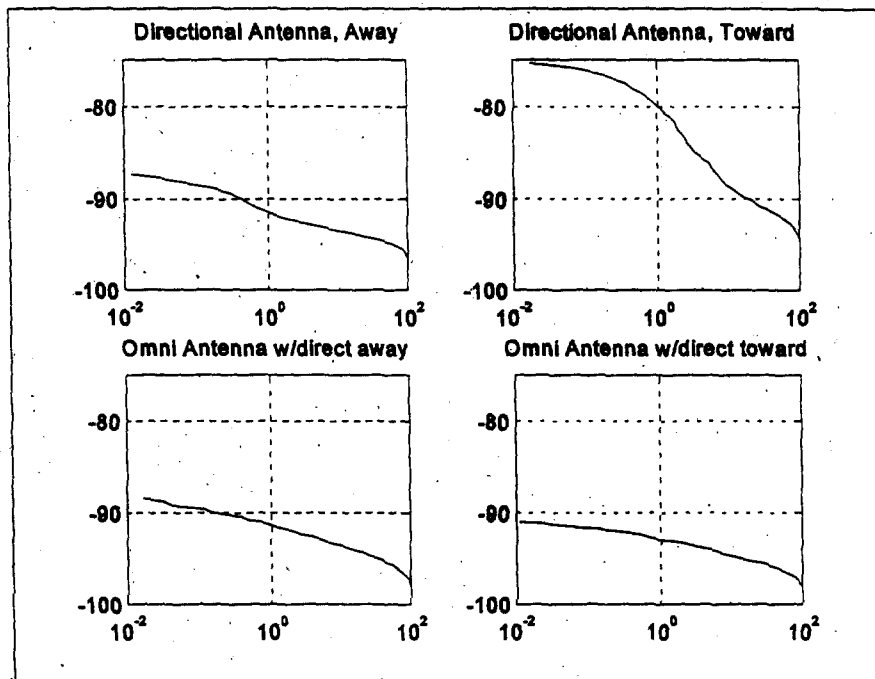


Figure 16: Los Angeles CA Data, 2450 MHz, +Peak Mode, 3 MHz Receiver BW, Amplitude(dBm) vs Percentage of Samples Exceeding that Amplitude

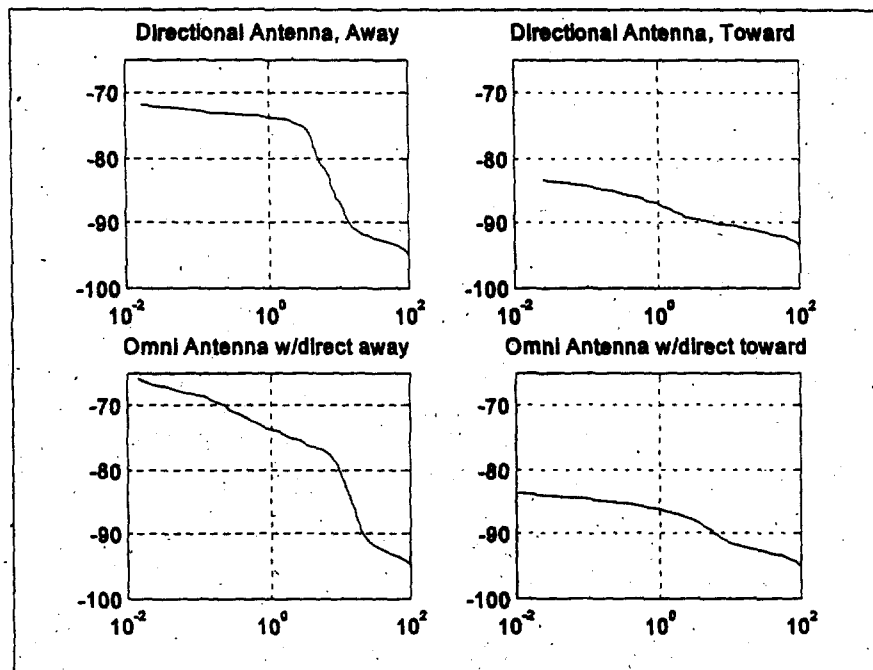


Figure 17: Downtown Denver CO Data, 2450 MHz, +Peak Mode, 3 MHz Receiver BW, Amplitude(dBm) vs Percentage of Samples Exceeding that Amplitude

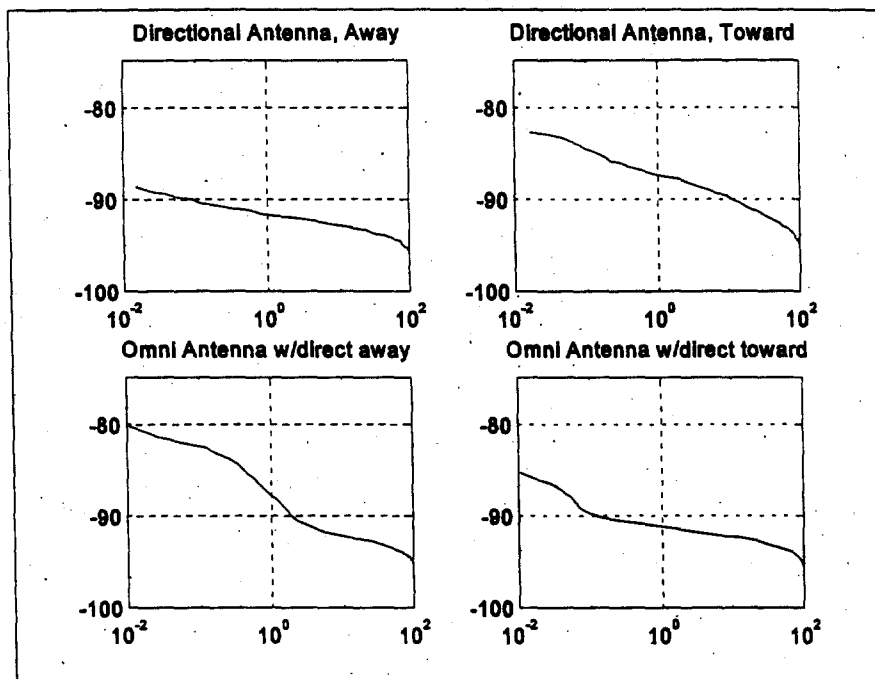


Figure 18: Genesee Mountain CO Data, 2450 MHz, +Peak Mode, 3 MHz Receiver BW, Amplitude(dBm) vs Percentage of Samples Exceeding that Amplitude.

## SECTION 4

### RESULTS

#### CONCLUSIONS

- The primary conclusion of the test effort is that the characteristics of the aggregate signal in the ISM band (2400-2500 MHz) are dependant on the receiver's location with respect to dominant oven sources. Away from those sources, the aggregate signal can be viewed statistically as elevated gaussian random noise. This is not unexpected, as the random spatial distribution of the domestic microwave ovens, and the attendant random start-phase nature of their magnetron signal sources intuitively rule out any kind of a "coherent addition" signal process. The amount of "elevation" is obviously frequency-dependent, with 3-10 dB being the norm over the band 2420-2480 MHz.
- In a downtown location, the aggregate emission environment was composed of a background composite signal similar to that described above, plus a component due to nearby dominant microwave oven sources. Characteristics of that dominant oven component are described in reference 4, and of particular note is that depending on the tuning of the victim receiver with respect to the oven transmission, the signals can be anywhere from 8 milliseconds to tens of microseconds or less in length. This is due to the fact that as the receiver is tuned farther and farther from the transmitted oven pulse frequency, only the wideband energy present in the leading and trailing edges of that pulse are captured by the receiver. Excitation of the impulse response of the receiver (in our case the spectrum analyzer) intermediate frequency (IF) filter results in the characteristic "rabbit ears" time waveforms, degenerating as off-tuning progresses to simply two low-level narrow-in-time pulses. Note that on-tune the dominant oven signals can be 30 dB or more stronger than the background aggregate signal. For this reason it is important that designers of equipment to be used in the 2400-2500 MHz band consider the effects imposed by those dominant oven sources, especially if the equipment is to be used in a downtown location.
- The background aggregate signal measured away from dominant oven sources did not display any diurnal variation. This was not expected. If, as hypothesized, domestic microwave ovens were the primary contributors to the aggregate signal, then the levels should peak during the mealtime hours -- a hypothesis supported by the diurnal variation evident when "dominant ovens" were present.



# INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION BUREAU

5985

UIT TELEFAX

22 MARS 1994

N°

TO MEMBERS OF FORMER TASK  
GROUP 1/2 OF RADIOCOMMUNICATION  
STUDY GROUP 1

Ref.: 02(SGA)/0.0681/94

Tel.: +41 22 730 5815

Fax: +41 22 730 5785

Subject: Task Group 1/2

21 March 1994

Dear Colleague,

I am pleased to report that the draft Recommendation produced by Task Group 1/2 (formerly CCIR IWP 1/4) was approved on 10 March 1994 by the Radiocommunication Study Group 1 with only a few minor edits.

As all of you know, it took a long time to develop a consensus on the many difficult and controversial issues contained in Question 70/1. We should all be proud of the work that was accomplished in Task Group 1/2.

I would like to take this opportunity to extend my personal thanks to each of you for your contributions to the Task Group and the final Recommendation. It was my pleasure to have known and worked with you. Best wishes in your future endeavours.

The work of the Task Group is now complete and it has been disbanded.

Yours sincerely,

*Art Wall*  
Art Wall

Chairman of former Task Group 1/2



Received: 14 December 1993

Chairman, Task Group 1-2

CHAIRMAN'S REPORT  
ON THE  
FINAL MEETING OF TASK GROUP 1-2  
(Paris, 16-17 September 1993)

I am pleased to report that Task Group 1/2 has completed its task by producing an answer to Question 70/1 in the form of the attached Draft Recommendation ITU-R [Doc.1/64]. The Draft is now ready for consideration and adoption by Study Group 1.

The Draft Recommendation is the result of the efforts of many experts from both ITU-R TG-1/2 (formerly CCIR IWP 1/4) and the International Special Committee for Radio Interference (CISPR) over a period of twelve years. The issues involved in developing a recommendation for limits for controlling the interference from Industrial, Scientific and Medical (ISM) equipment to radiocommunication services are both controversial and political. The Draft Recommendation represents what we believe is the best compromise that can be reached on these issues.

Briefly, the Draft recommends that administrations consider the latest edition of CISPR Publication 11 as a guide for the application of limits for RF emissions on frequencies outside the designated bands for ISM applications and methods for ISM equipment regulations. Note that it does not recommend that CISPR Publication 11 should be adopted into the ITU Radio Regulations, since a number of countries believe they have sufficient safeguards to protect radiocommunication services. Limits for emissions within the ITU bands designated for ISM use was a particularly difficult issue to resolve, since ISM manufacturers believe that limits within these bands may have the effect of discouraging or limiting future ISM applications. In addition, TG 1/2 was never able to determine the ultimate purpose and use of in-band limits. As a compromise, Table II of the Annex to the Recommendation provides a range of measured field strength values in the ISM bands. It is suggested that administrations use these levels as guidelines in planning radio services. The Annex to the Recommendation also provides a wealth of information about current and future ISM equipment applications. This information should be useful in planning future radio services.

Continued cooperation with the CISPR is also recommended to ensure that radio services are adequately represented for protection from other sources of interference, e.g., home appliances and Information Technology Equipment. Noting that the development of out-of-band limits for ISM and other non-communication equipment is an ongoing process within the CISPR, an active ITU-R liaison would serve to enhance the role of both organizations.

A preliminary draft of the Recommendation was circulated to members of the Task Group on 24 March 1993 in Doc.1-2/3. A meeting of TG 1/2 was held on 16-17 September 1993 in Paris to discuss the comments. Most of the comments were considered editorial and were incorporated into the Draft Recommendation at the meeting. One set of comments, however, was handled by correspondence with the author.

In summary, the Draft Recommendation ITU-R [Doc.1/64] represents what I believe is the best compromise we can expect with respect to Question 70/1. It is, therefore, respectfully submitted to SG 1 for its consideration and adoption.

---



INTERNATIONAL TELECOMMUNICATION UNION

**RADIOCOMMUNICATION  
STUDY GROUPS**

Document 1/64-E  
11 November 1993  
Original: English

---

Received: 11 November 1993

Subject: Question 70/1

Task Group 1/2

DRAFT NEW RECOMMENDATION [DOC. 1/64]

**LIMITATION OF RADIATION FROM INDUSTRIAL,  
SCIENTIFIC AND MEDICAL (ISM) EQUIPMENT**

(Question 70/1)

The ITU-R,

**considering**

- a) that Provision No. 16 of the Radio Regulations defines ISM applications (of radio-frequency energy) as operation of equipment or appliances designed to generate and use locally radio-frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications;
- b) that ISM equipment has the potential to cause harmful interference to radiocommunication services and applications throughout the spectrum;
- c) that for the optimum use of the frequency spectrum, it is necessary to lay down limits of radiation from ISM equipment outside the bands designated for their use;
- d) that WARC-79 with its Resolution No. 63 invited the ITU-R to specify, in collaboration with IEC/CISPR, limits to be imposed on radiation from ISM equipment inside and outside the bands designated in the Radio Regulations for their use;
  - that limits shall be specified in the entire radio spectrum allocated to radio services;
  - that different radio services need different grades of protection and that the specific protection requirements of safety services and safety communications need to be taken into account;
  - that the use of radio-frequency energy for industrial, scientific, medical and domestic purposes is beneficial for the economy and the consumers, and is essential for a number of these applications;
- e) that due to the different operating environments and characteristics of ISM equipment several categories of limits are necessary;
- f) that radio services operating in the bands designated for use by ISM equipment prior to WARC-79 are required to accept harmful interference and that radiation limits are necessary in all other bands to protect radio services;

- g) that radiation from ISM equipment may be costly and technically difficult to suppress and thus development of suppression requirements must take into consideration physical, technological, economic, operational and safety aspects of ISM usage to avoid unnecessarily severe measures;
- h) that equipment meeting the radiation limits, which are compromise values, may in some circumstances cause harmful interference; and, there needs to be provisions for measures to be taken to eliminate or reduce interference in individual cases;
- j) that the legal and administrative provisions differ in different countries and thus administrations have different methods of applying and enforcing limits;
- k) that the CISPR has developed limits and taken into account the principles outlined in **considerings f) and g)** and the requirements to harmonize the procedures for the control of interference in order to eliminate technical barriers to trade;
- l) that the interference potential depends on the location of ISM equipment within the user's premises and that the measuring distance and the point of reference for in situ measurements have to be taken into account;
- m) that severe difficulties could arise if different limits were to be recommended by different international bodies for the same class of equipment,

#### **noting**

- 1. that, for ISM applications, the frequencies typically used by ISM equipment and some current and future ISM applications are shown in the annex;
- 2. that, although the ITU has designated specific frequency bands for ISM applications, other operating frequencies are also being used where practical constraints do not permit the usage of the designated bands;
- 3. that CISPR Publication 23 "Determination of limits for industrial, scientific and medical equipment" provides details of the derivation of limits;
- 4. that while Information Technology Equipment (ITE) and RF lighting devices use RF energy, they have not been considered by the CISPR as ISM equipment and therefore are dealt with in CISPR Publications 15 and 22, respectively,

#### **recommends**

- 1. that administrations consider the use of the latest edition of CISPR Publication 11, including amendments, as a guide for the application of limits and methods of measurements for ISM equipment regulation in order to protect radiocommunications;
- 2. that there should be continued cooperation with the CISPR to ensure that radiocommunication needs are fully taken into consideration.

## ANNEX 1

**Industrial, scientific and medical (ISM) applications****1. Introduction**

This annex includes the ITU definition of ISM applications, a list of frequencies typically used by ISM equipment and describes some current and future ISM applications.

**2. ISM applications**

According to ITU Radio Regulation 16, ISM application is the operation of equipment or appliances designed to generate and use locally radio-frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications.

A partial list of ISM applications and equipment include:

**Induction heating equipment (below 1 MHz)\***

- domestic induction cookers
- metal melting
- billet heating
- tube welding
- soldering and brazing
- component heating
- spot welding
- selective surface heat treating of metal parts
- semiconductor crystal growing and refining
- seam bonding of autobody surfaces
- package sealing
- heating strip steel for galvanizing, annealing and paint drying

**RF dielectric heating equipment (1 - 100 MHz)**

- veneer and lumber drying
- textile drying
- fibreglass drying
- paper and paper coating drying
- plastic preheating
- plastic welding and moulding
- food post baking and drying
- meat and fish thawing
- foundry core drying
- glue drying
- film drying
- adhesive curing
- material preheating

**Medical equipment**

- short-wave and microwave diathermy and hyperthermia equipment
- electrical surgical units (ESU)
- magnetic resonance imaging (MRI)
- ultrasonic diagnostic imaging

**Microwave equipment (above 900 MHz)**

- domestic and commercial microwave ovens
- food tempering, thawing and cooking
- UV paint and coating curing
- rubber vulcanization
- pharmaceutical processing

**Miscellaneous equipment**

- RF excited arc welders
- spark erosion equipment

**Laboratory and scientific equipment**

- signal generators
- measuring receivers
- frequency counters
- flow meters
- spectrum analysers
- weighing machines
- chemical analysis machines
- electronic microscopes
- switched mode power supplies (not incorporated in an equipment)

## 2.1 Current applications

The frequencies currently employed for industrial, scientific, medical and other non-communications applications cover a very wide spectrum including frequencies other than those designated by the Radio Regulations. A number of ISM equipments use frequencies of undefined tolerance and stability and some of them use frequencies allocated to the safety services and radionavigation services. Table 1 provides a summary of some of the ISM applications in various frequency bands.

**TABLE 1**  
**ISM equipment in current use**

Frequency (MHz)	Major applications	RF power (typical)	Estimated No. in use
Below 0.15	industrial induction heating (welding and melting of metals)	10 kW - 10 MW	>100 000
	ultrasonic cleaning (15 - 30 kHz)	20 - 1 000 W	>100 000
	medical applications (ultrasonic diagnostic imaging)	100 - 1 000 W	>10 000
0.15 - 1	induction heating (heat treating, package sealing, welding and melting of metals)	1 kW - 1 MW	>100 000
	ultrasonic medical diagnostics	100 - 1 000 W	>100 000
1 - 10	surgical diathermy (1 - 10 MHz dampened wave oscillator)	100 - 1 000 W	>100 000
	wood gluing and wood curing (3.2 and 6.5 MHz)	10 kW - 1.5 MW	
	valve induction generators	1 - 200 kW	>1 000
	production of semi-conductor material RF arc stabilized welding (1 - 10 MHz dampened wave oscillator)	2 - 10 kW	>10 000

TABLE 1-(continued)

Frequency (MHz)	Major applications	RF power (typical)	Estimated No. in use
10 - 100	<p>dielectric heating (majority operate on frequencies in the ISM bands at 13.56, 27.12 and 40.68 MHz, but many also operate on frequencies outside the ISM bands)</p> <ul style="list-style-type: none"> <li>- ceramics</li> <li>- foundry core drying</li> <li>- textile drying</li> <li>- business products (books, paper, gluing and drying)</li> <li>- food (post baking, meat and fish thawing)</li> <li>- solvent drying</li> <li>- wood drying and gluing (veneer and lumber drying)</li> <li>- general dielectric drying</li> <li>- plastic heating (die sealing and plastic embossing)</li> </ul> <p>medical applications</p> <ul style="list-style-type: none"> <li>- medical diathermy (27 MHz)</li> <li>- Magnetic Resonance Imaging (10 - 100 MHz in large shielded rooms)</li> </ul>	<p>15 - 300 kW</p> <p>15 - 300 kW</p> <p>15 - 200 kW</p> <p>5 - 25 kW</p> <p>10 - 100 kW</p> <p>5 - 400 kW</p> <p>5 - 1 000 kW</p> <p>1 - 50 kW (most &lt; 5 kW)</p> <p>100 - 1 000 W</p>	<p>&lt;1 000</p> <p>&lt;1 000</p> <p>&gt;1 000</p> <p>&gt;1 000</p> <p>&lt;1 000</p> <p>&gt;10 000</p> <p>&gt;100 000</p> <p>&gt;10 000</p> <p>&gt;1 000</p>
100 - 1 000	<p>food processing (915 MHz)</p> <p>medical applications (433 MHz)</p> <p>RF plasma generators</p> <p>rubber vulcanization (915 MHz)</p>	<p>&lt;200 kW</p>	<p>&lt;1 000</p> <p>&lt;1 000</p>
above 1 000	<p>RF plasma generators</p> <p>domestic microwave ovens (2 450 MHz)</p> <p>commercial microwave ovens (2 450 MHz)</p> <p>rubber vulcanization (2 450 MHz)</p> <p>RF excited ultraviolet curing</p>	<p>600 - 1 500 W</p> <p>1.5 - 200 kW</p> <p>6 - 100 kW</p>	<p>&gt;200 million</p> <p>&lt;1 000</p>

## **2.2 Future applications**

Investigations into new non-communication applications of electromagnetic energy for improving industrial processes are dramatically increasing throughout the world. These investigations are not limited to the ISM bands. Selection of the application frequency for production apparatus is based on many factors, which include, but are not limited to: a) availability of a suitable power source; b) RF interference potential and containment costs; c) safety considerations; d) availability of a suitable ISM frequency; and, e) frequency optimization for the particular operation. A number of new applications promise significant social and economic benefits, which may not be available by any other process and also promise significant savings in energy and the environment.

Areas of recent investigations include:

### **2.2.1 Induction heating**

While not a new application, new high-flux induction generators are encouraging a number of applications, such as:

- 1) refining of very pure semi-conductor material;
- 2) melting of metals, particularly vacuum melting for the aerospace and automotive industries.

### **2.2.2 Plasma chemistry**

The ISM bands at 27 MHz, 915 MHz and 2 450 MHz, as well as other frequencies are being investigated in the following plasma chemistry experiments:

- 1) diamond growing;
- 2) ceramic processing and sintering;
- 3) raw material processing.

### **2.2.3 Medical treatment**

Some recent investigations include:

- 1) acceleration of chemical analysis using 2 450 MHz;
- 2) local radiation treatment for cancer on frequencies below 400 MHz (hyperthermia);
- 3) tissue fixation;
- 4) magnetic resonance imaging using 10 to 100 MHz in specially shielded rooms;
- 5) treatment of hyperthermia.

### **2.2.4 Material and food processing**

- 1) environment space heating using 5 800 MHz;
- 2) recovery of oil for shale using frequencies below 10 MHz;
- 3) disposal of hazardous waste using microwave frequencies like 2 450 MHz;
- 4) bulk thawing and cooking at 915 MHz, 2 450 MHz and 5 800 MHz;
- 5) clothes drying at 2 450 MHz;
- 6) soil remediation;
- 7) medical waste sterilization;
- 8) pasteurization and sterilization of foods;
- 9) treatment of refuse (13.56 MHz and 2 450 MHz).

### **2.2.5 Power transfer**

Most experiments on transfer of energy have occurred at microwave frequencies, e.g., 2 450 MHz, 5 800 MHz and higher.

- 1) Solar power satellite experiments are continuing at 2 450 MHz and 35 GHz;
- 2) transfer of power to an aircraft at 2 450 MHz;
- 3) electrified roadway - a number of energy transfer stations embedded in the roadway to recharge electrically powered vehicles passing overhead (915 MHz and 2 450 MHz);
- 4) EM propulsion systems below 1 MHz.

## **3. Radiation levels inside the bands designated for ISM applications**

### **3.1. Rationale**

There are at least five reasons for setting in-band limits for ISM equipment, which are:

- 1) to control bioeffects;
- 2) to minimize out-of-band emissions for the protection of radio services;
- 3) to minimize in-band emissions for the protection of radio services operating in the ISM bands;
- 4) to minimize radio emissions for the protection of adjacent band radio services;
- 5) to minimize radio emissions to protect electronic or radio services operated in the immediate vicinity of ISM equipment.

The limits and methods of measurement and methods employed for bioeffects compliance are outside the scope of the ITU and the CISPR and therefore bioeffect could not be used for setting in-band limits. However, it has been observed that, in many cases, compliance with the biological effects limits has not substantially reduced radiation levels at CISPR measuring distances.

It should be noted reducing in-band radiation does not necessarily reduce out-of-band radiation, and that the out-of-band radiation can increase through suppression of in-band signals.

In-band limits to protect in-band radio services have not been considered because the services to be protected have not been specified. Furthermore, the setting of restrictive limits will decrease the usefulness of the ISM bands for industrial purposes. The result of this would be to encourage the use of ISM equipment in frequency ranges more suitable to their processes, but detrimental to radio services.

The use of in-band limits to protect radio services adjacent to the ISM bands or to protect electronic or radio equipment in the vicinity of ISM operations is more properly dealt with as an equipment immunity issue. Therefore, this is best resolved by ensuring necessary distance separation or by incorporating adequate immunity characteristics in potential victim equipment. However, the calculation and realization of immunity is practical only if the field strengths to be encountered in practice are known. For this reason, the following table of measured levels of radiation based on measurements in a number of different countries is supplied.

### **3.2 ITU designated ISM bands and measured levels**

Some measurements of the radiation levels generated by ISM equipment in the bands designated for their use have been carried out in different countries and at different locations. Table 2 gives a survey of the results.

TABLE 2

**Range of measured levels of field strength from ISM equipment  
in the ITU-designated ISM bands**

Frequency band	Centre frequency	No. of appropriate footnote to the Table of Frequency Allocations of the ITU Radio Regulations	Range of measured field strengths (dB(uV/M))(1)
6.765 - 6.795 MHz	6.78 MHz	524	80-100
13.553 - 13.567 MHz	13.567 MHz	534	80-120
26.957 - 27.283 MHz	27.12 MHz	546	70-120
40.66 - 40.70 MHz	40.68 MHz	548	60-120
433.05 - 434.79 MHz	433.92 MHz	661, 622 (Region 1)	60-120
902 - 928 MHz(2)	915 MHz	707 (Region 2)	60-120
2 400 - 2 500 MHz	2 450 MHz	752	30-120
5.725 - 5.825 GHz	5.8 GHz	806	No information
24.00 - 24.25 GHz	24.125 GHz	881	No information
61.00 - 61.50 GHz	61.25 GHz	911	No information
122 - 123 GHz	122.5 GHz	916	No information
244 - 246 GHz	245 GHz	922	No information

Note 1 - The field strength is that existing at a distance of 30 m from the boundary of the building in which the ISM equipment is situated. Therefore the actual distance between the ISM equipment and the measuring point is not known.

Note 2 - 896 MHz in the United Kingdom.

#### 4. Sources for more information

1) Journal and Symposium Reports of the  
International Microwave Power Institute  
13542 Union Village Circle  
Clifton, VA 22024  
United States

2) Electric Power Research Institute  
P.O. Box 10412  
Palo Alto, CA 94303  
United States

3) U.I.E.  
International Union for Electroheat  
Monsieur G. Vanderschueren  
Secrétaire Général  
Tour Atlantique  
CEDEX 6  
F-92080 PARIS LA DEFENSE  
France

Tel: (33 1) 47 78 99 34  
Fax: (33 1) 49 06 03 73



<b>VOTE ON COMMITTEE DRAFT</b>	
Reference number <b>CISPR/B/157/CDV</b>	
Date of circulation <b>1995-09-22</b>	Closing date for voting <b>1996-02-29</b>
Project number <b>CISPR 11 f2 Ed. 3</b>	

Please send this form, duly completed, to the Central Office, with copy to the secretary indicated below. P-members of the technical committee or subcommittee concerned have an obligation to vote.

<b>IEC/TC or SC: CISPR/B</b>  Title: Interference relating to industrial, scientific and medical radio-frequency apparatus	<b>Secretary (name and address):</b> Mr. Masuo Okamura Secretary IEC/CISPR/B Director EMC Engineering Lab. Japan Quality Assurance Organization 21-25, Kinuta 1-Chome Setagaya-ku TOKYO 157 Japan
<b>Title of the committee draft:</b> Guidelines for emission levels within the bands designated by the ITU for ISM application	

- ☐ We agree to the circulation of the draft as an FDIS in accordance with 2.7.1 of part 1 of the ISO/IEC Directives.
- ☐ with comments (editorial or other appended)
- ☐ We do not agree to the circulation of the draft as an FDIS  
The reasons for our disagreement are the following (use a separate page as annex, if necessary):

Vote and Comments  
to USNC/IEC Office  
by **FEB 15 1996**

☐ We abstain

National Committee voting: .....	Name: .....
Date: .....	Signature: .....



COMMITTEE DRAFT

Date of circulation

September 1995

Reference number (assigned by Central Office)

CISPR/B/157/CDV

Supersedes document

CISPR/B(Secretariat)105

Project number

CISPR 11 f2. Ed. 3

THIS DOCUMENT IS STILL UNDER STUDY AND SUBJECT TO CHANGE. IT SHOULD NOT BE USED FOR REFERENCE PURPOSES.

IEC/TC or SC: CISPR Sub-Committee B

Title: Interference relating to Industrial, Scientific and Medical (ISM) Radio-Frequency Apparatus

Secretary: Masuo Okamura

Title: Guidelines for emission levels within the bands designated by the ITU for ISM application

(Title): Lignes directrices concernant les niveaux d'émission dans les bandes désignées par l'UIT pour les applications ISM

Circulated to P- and O-members, and to technical committees in liaison, for:

- discussion at .....
- comments by ...1996-02-29
- voting (P-members only: ballot form attached. P-members of the technical committee or sub-committee concerned have an obligation to vote), for approval for circulation as a DIS (see 2.5.8 of part 1 of the ISO/IEC Directives) by:  
...1996-02-29

**Introductory note**

In 1979, the World Administration of Radio Conference adopted Resolution 63, in which WARC invited CCIR (ITU/R) to develop the limits both in-band and out-of-band radiation limits in cooperation with CISPR. This CDV is in line with the conclusion of ITU/R (CCIR) TG1/2 Studygroup 1.